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Geology of

Carbonatite – Alkalic Rock Complexes in Ontario:

Valentine Township Carbonatite Complex

District of Cochrane

Ontario Geological Survey
Study 39

by R. P. Sage

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Foreword

The Valentine Township Carbonatite Complex was examined as part of a project to study alkalic rock – carbonatite complexes in Ontario. The study describes the rock types and mineralogy of the complex and outlines the history of the mineral exploration efforts within the complex.

V.G. Milne

Director
Ontario Geological Survey

Contents

Abstract 2
Résumé 2
Introduction 3
Acknowledgments 3
Location and Access 3
Laboratory Technique 3
Previous Work 3
Nomenclature 3
General Geology 6
Late Precambrian 8
Fenite 8
Silicocarbonatite 9
Sovite 10
Petrology 11
Geochronology 11
Metamorphism 12
Structural Geology 12
Geophysical Expression 12
Recommendations For Future Study 13
Economic Geology 14
Property Description 14
Argor Explorations Limited 14
Recommendations To The Prospector 14
Appendix A — Petrographic Descriptions, Chemical Analyses, Normative Compositions, And Statistical Compositions Of Lithologic Units 15
References 35
Index 36

Tables

1. Table Of Lithologic Units 8
2. Microprobe Analyses Of Mineral Grains 10
A–1. Petrographic Descriptions Of Whole–rock Samples 15
A–2. Major Element Analyses Of Whole–rock Samples 21
A–3. Trace Element Analyses Of Whole–rock Samples 24
A–4. Normative Minerals For Whole–rock Samples 29
A–5. Average Chemical Compositions Of Lithologic Units 34

Figures

1. Key Map 4
2. Aeromagnetic Map 6
3. Detailed Aeromagnetic Map, Showing Locations Of Drillholes 7
4. Sections Through Drillholes 7

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Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Geology of
Carbonatite – Alkalic Rock Complexes in Ontario:
Valentine Township Carbonatite Complex
District of Cochrane

R.P. Sage[1]

1. Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by John Wood, Chief Geologist, Ontario Geological Survey, May 31, 1983.

This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

The Valentine Township Carbonatite Complex is located in the northern portion of the Kapuskasing Subprovince of the Superior Province of the Canadian Shield. The intrusion was likely emplaced into one of the many northeast–trending zones that characterize this subprovince. The carbonatite does not outcrop at surface but lies buried beneath a minimum of 120 m of overburden and Paleozoic rocks. The age of the complex is unknown but it is assumed to be Late Precambrian and coeval with most alkalic rock – carbonatite events within the Kapuskasing Subprovince.

Limited diamond drilling of the complex indicates it is composed of sovite, silicocarbonatite, and fenitized country rock. Drilling has also indicated the presence of widespread but sub–economic concentrations of niobium and phosphorus. Lost core at the surface of the carbonatite suggests the possibility of a weathered residuum on its surface.

The complex warrants additional testing to check for residual apatite deposits at the Paleozoic–Precambrian unconformity and to outline concentrations of niobium and phosphorus within the complex. The rare earth element content warrants checking.

Résumé

Le complexe de carbonatite du canton de Valentine se trouve dans la partie Nord de la sous–province de Kapuskasing, dans la province Supérieure du bouclier canadien. L'intrusion était sans doute située dans une des nombreuses zones orientées vers le nord–est et qui caractérisent cette sous–province. La carbonatite n'affleure pas la surface mais est enfouie sous au moins 120 m de morts–terrains et de roches paléozoiques. On ne connaît pas précisément l'âge du complexe mais on estime qu'il date du Précambrien supérieur, soit de la même période que la plupart des roches alcalines et des formations de carbonatite de la sous–province de Kapuskasing.

Les quelques forages au diamant effectués indiquent que le complexe est formé de sovite, de silicocarbonatite et de roche encaissante fénitisée. Ces forages ont également révélé la présence généralisée de niobium et de phosphore mais à des concentrations insuffisantes pour être commercialisés. La présence de noyaux perdus à la surface de la carbonatite semble indiquer la possibilité d'un résidu désagrégé à la surface.

Il y aurait lieu de procéder à une étude additionnelle du complexe en vue de déceler la présence de gîtes résiduels d'apatite de discordance paléozoique–précambrienne et de déterminer les concentrations de niobium et de phosphore au sein du complexe. La teneur en terre rare devrait également être déterminée.

Geology of Carbonatite – Alkalic Rock Complexes in Ontario: Valentine Township Carbonatite Complex, District of Cochrane, by R.P. Sage. Ontario Geological Survey, Study 39, 37p. Published 1988. ISBN 0–7729–0574–6.

Introduction

The Valentine Township Carbonatite Complex occurs within the northern portion of the Kapuskasing Subprovince of the Superior Province and is one of seven such complexes in the area (Satterly 1968). The intrusion lies beneath Paleozoic cover rocks and its overall shape is unknown. The complex was discovered by diamond drilling by Argor Explorations Limited in 1967 but was tested by only limited drilling due to its location beneath Paleozoic cover.

Acknowledgments

The author wishes to thank Mr. Arthur Stollery, Morrison Petroleums Limited, formerly Consolidated Morrison Explorations Limited, for permission to sample drill core from the Valentine complex, and Mr. A. Michel, Moosonee, for help at the core shed. The author was assisted in the sampling process by Mr. L. Luhta, resident geologist, Ontario Ministry of Natural Resources, Timmins. In 1988, the statistics on rock chemistry were recalculated by Mr. A. Lisowyk.

Location and Access

The Valentine Township Carbonatite Complex (Figure 1) is located beneath marshy ground of the James Bay Lowlands and is easily accessible only by helicopter. The area can also be reached by taking the Ontario Northland Railway along the Abitibi River to just north of Coral Rapids which lies in the southwest corner of Valentine Township, and then crossing the river by canoe to the east side. The centre of the carbonatite is 4–5 km east of the river (see Figure 3). The carbonatite is located at approximately 50°15' N Latitude and 81°37' W Longitude. The area is generally swampy and of low relief.

Laboratory Technique

Samples of core were selected for their homogeneous nature. A portion of each sample was submitted for analysis and a thin section was prepared from the remaining portion, leaving a small chip for reference. Petrographic descriptions of the carbonatite are restricted to these thin sections.

Previous Work

No previous work has been reported on the Valentine Township Carbonatite Complex, however the region was mapped on a reconnaissance scale by Bennett *et al.* (1966, 1967).

Nomenclature

In describing the lithology of the Valentine Township Carbonatite Complex the author has used only two rock names to describe the carbonatite rocks: sovite and silicocarbonatite.

Sovite. A carbonatite rock composed of 50% or more calcite. Various mineralogic modifiers are used to classify the sovite.

Silicocarbonatite. A carbonate–rich rock containing 50% or more oxide and silicate minerals. Where the silicate or oxide minerals make up more than 90% of the rock, various other rock names are applied; i.e. ijolite, biotite, pyroxenite, etc.

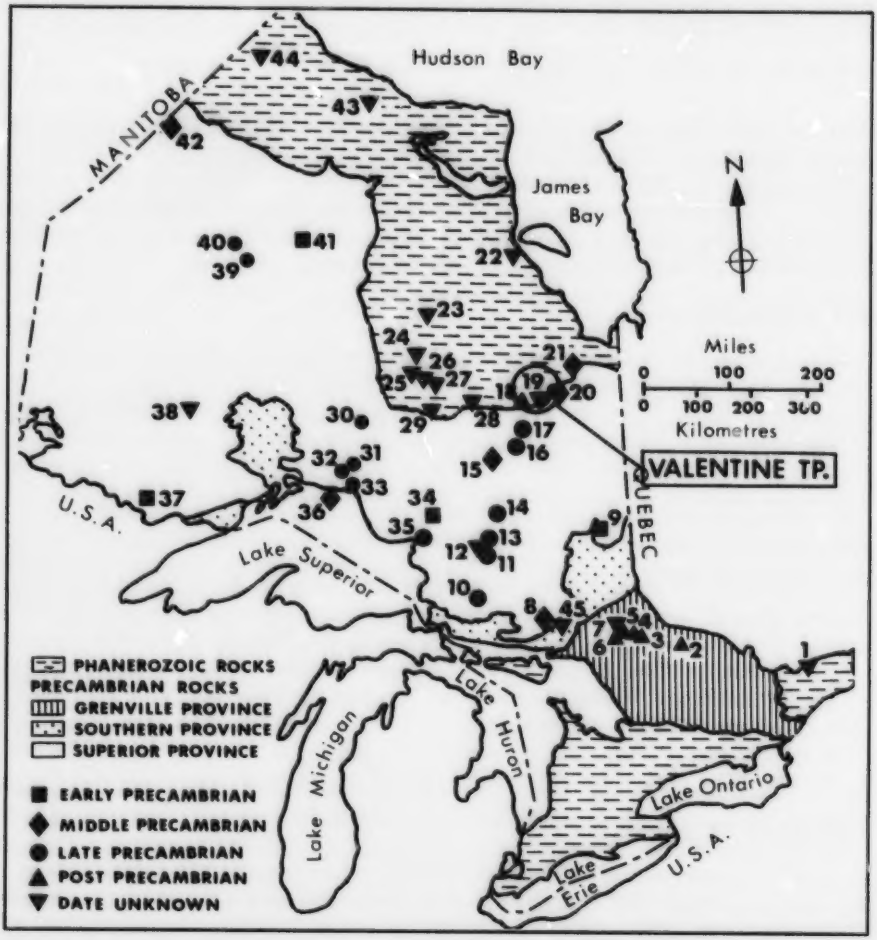

Figure 1. *Key map showing location of carbonatite - alkalic rock complexes in Ontario.*

1. *Eastview*
2. *Brent*
3. *Callander B.*
4. *Manitou Is.*
5. *Burritt Is.*
6. *Iron Is.*
7. *Lavergne*
8. *Spanish R.*
9. *Otto Stock*
10. *Seabrook L.*
11. *Lackner L.*
12. *Borden Tp.*
13. *Nemegosenda L.*
14. *Shenango Tp.*
15. *Cargill Tp.*
16. *Teetzel Tp.*
17. *Clay-Howells*
18. *Hecla-Kilmer*
19. **Valentine Tp.**
20. *Goldray*
21. *Argor*
22. *Lawashi R.*
23. *Poplar R.*
24. *Albany Forks*
25. *L. Drowning R.*
26. *Kingfisher R. West*
27. *Kingfisher R. East*
28. *Martison L.*
29. *Nagagami R.*
30. *Chipman L. (dikes)*
31. *Killala L.*
32. *Prairie L.*
33. *Port Coldwell*
34. *Herman L.*
35. *Firesand R.*
36. *Slate Is.*
37. *Poohbah L.*
38. *Sturgeon Narrows & Squaw L.*
39. *Schryburt L.*
40. *Big Beaver House*
41. *Wapikopa L.*
42. *"Carb" L.*
43. *Gooseberry Br.*
44. *Niskibi L.*
45. *Nemag L. & Lusk L.*

The definitions of sovite and silicocarbonatite are modified from Heinrich (1966, p.12). The author has found Heinrich's subdivision of the carbonate–rich carbonatitic rocks generally suitable for field usage when modified to a two–fold subdivision at about 50% oxide and silicate mineral contents. The two–fold subdivision is more convenient than the four–fold subdivision of Heinrich (1966) because carbonatites show extreme variations in mineral content over distances of less than a few centimetres. It is difficult to rigorously classify such heterogeneous rocks.

General Geology

The Valentine Township Carbonatite Complex (Figures 2, 3, 4) lies beneath 123 to 150 m of overburden and Paleozoic sedimentary rocks. Overburden is of variable thickness from 16 to 55 m. The Paleozoic section consists of limestone of the Middle Devonian Kwataboahegan formation and sandstone of the Lower Devonian Sextant Rapids formation (diamond drill logs, Argor Explorations Limited). The Paleozoic section varies from 71 to 101 m in thickness.

A zone of lost core in the drillholes occurs below the Paleozoic section and above the carbonatite. The thickest zone of lost core was in hole V2–1 between 134 and 177 m. Weathered carbonatite occurs from 127 to 166 m in hole V2–3. The lost core and reported weathering of the carbonatite suggests the possibility that a residuum derived from the carbonatite may locally be present on the carbonatite surface.

Below the zone of lost core the intrusion consists of magnetite–amphibole–biotite–phlogopite–apatite–olivine sovite and silicocarbonatite. The intrusion con-

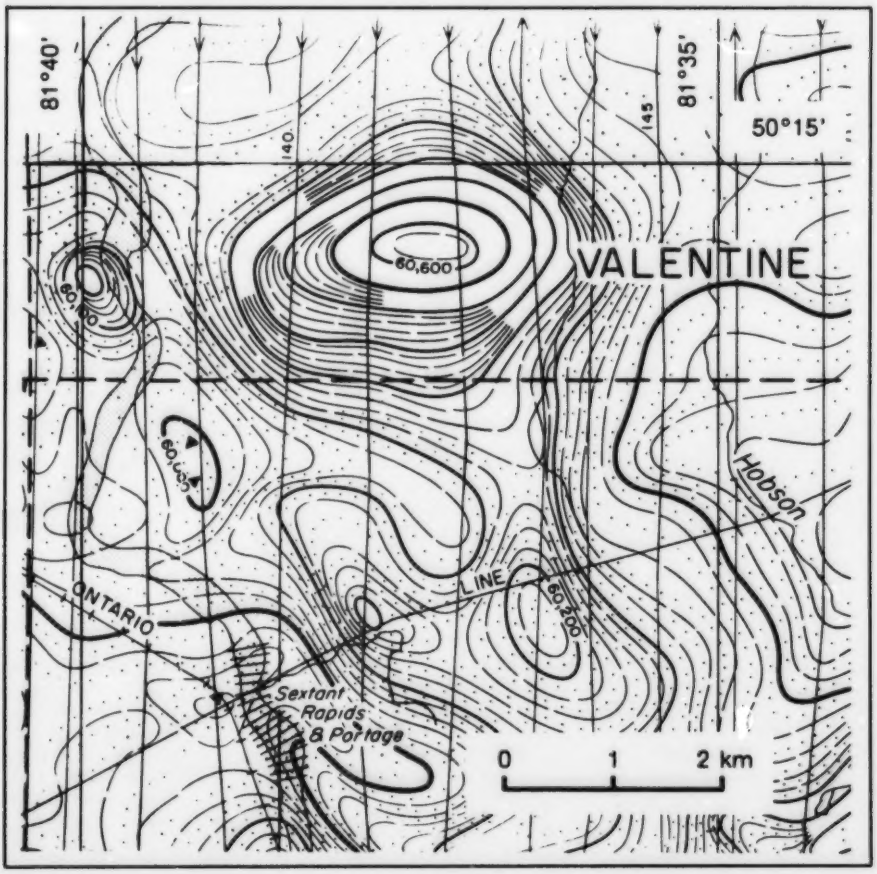

Figure 2. *Aeromagnetic map of the Valentine Township Carbonatite Complex. From aeromagnetic maps 2306G, 2307G (ODM–GSC 1964a,b).*

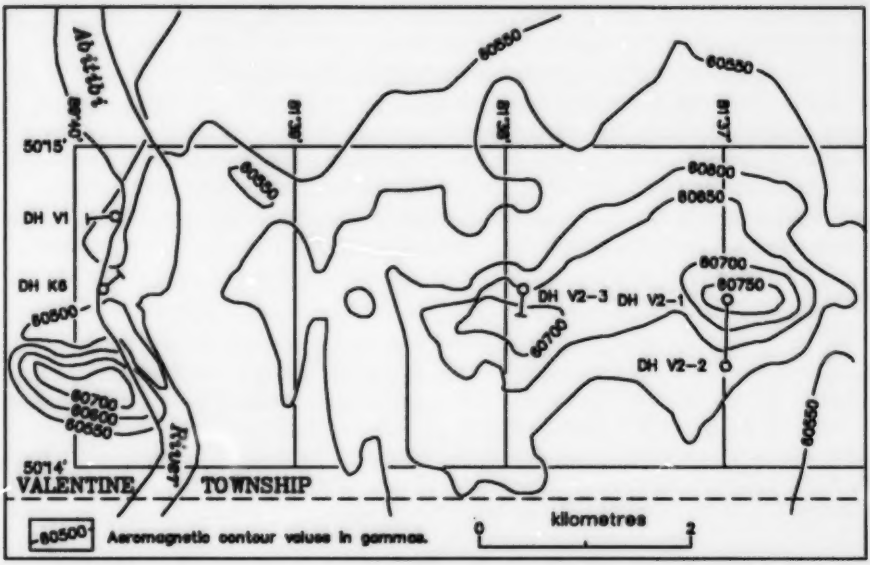

Figure 3. *Detailed aeromagnetic map of the Valentine Township Carbonatite Complex, showing locations of diamond drillholes by Argor Explorations Limited. Data compiled from File 63.2234, Assessment Files Research Office, Ontario Geological Survey, Toronto.*

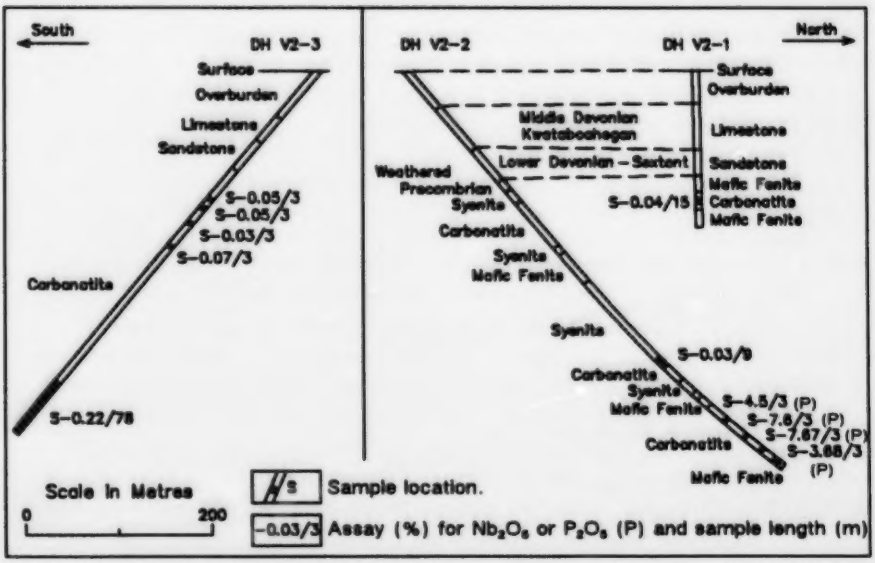

Figure 4. *Sections through diamond drillholes V2-1, V2-2, and V2-3 of Argor Explorations Limited. Data compiled from File 63.2234, Assessment Files Research Office, Ontario Geological Survey, Toronto.*

tains blocks of fenitized granitic gneiss which appear as syenite in drill logs of Argor Explorations Limited.

The magnetic data is somewhat inconclusive in outlining the shape of the complex, however a circular magnetic anomaly that fades into the background overlies the complex. The aeromagnetic anomaly is approximately 3.6 km in diameter (Figure 2). The carbonatite has a minimum surface area of 10.2 km^2 and may be considerably larger. The carbonatite has not been isotopically dated.

Table 1 gives the lithologic units for the Valentine Township Carbonatite Complex.

LATE PRECAMBRIAN

FENITE

In drill hole V2–2 several specimens appear to be highly altered granitic gneiss. Though quartz was not observed in the samples the author considers it likely that it was originally present and has been removed during alteration (fenitization). The alteration process is visualized as being one of sodium, iron, and carbon dioxide addition and silica subtraction. Fresh unaltered gneissic rock was not observed in any samples. These fenitized gneisses are interpreted to be Early Precambrian in age, based on correlation with gneissic rocks south of the James Bay Lowlands. In thin section the fenitized gneiss is equigranular, massive, allotriomorphic with curved to lobate grain boundaries. One sample is hypidiomorphic with poikiloblastic biotite. The mode is estimated to be 20–40% pyroxene, 0–30% plagioclase (An 6–8), 10–25% biotite, and 10–25% carbonate. Magnetite, amphibole, and apatite occur in minor amounts. Patches of very fine-grained alteration that occur in two specimens have blocky rectangular outlines which may indicate the former presence of nepheline.

The clinopyroxene is anhedral, somewhat ragged, colourless, and encloses an occasional bleb of carbonate. The plagioclase is albite in composition and forms

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE VALENTINE TOWNSHIP CARBONATITE COMPLEX.

CENOZOIC
Recent
Swamp and stream deposits.
Pleistocene
Sand and gravel.

Unconformity

PALEOZOIC
Devonian
Limestone, sandstone.

Unconformity

LATE PRECAMBRIAN

Valentine Township Carbonatite Complex

Sovite, silicocarbonatite.

Intrusive Contact

Fenitized gneissic rocks.

EARLY PRECAMBRIAN
Granitic gneiss (?)

anhedral irregular grains. Bending of the albite twin planes was noted in one sample and the plagioclase poikilitically encloses carbonate, clinopyroxene, biotite, and patches of a very fine grained brown alteration of unknown mineralogy.

Biotite forms brown anhedral to subhedral tabular grains which may interlock with clinopyroxene. One specimen contains biotite with small inclusions with dark haloes. These inclusions are thought to be zircon with radioactive bombardment haloes. The biotite encloses carbonate, apatite, and an unidentified fine-grained alteration. In the one poikiloblastic sample, biotite was the poikiloblastic mineral.

The carbonate is anhedral, interstitial, and forms an interlocking mosaic of grains. Carbonate forms part of the largely unidentifiable patches of alteration.

The amphibole is acicular and pleochroic in various shades of green. The opaques are disseminated and anhedral. Apatite occurs as subhedral, round to round-elongate grains.

SILICOCARBONATITE

Silicocarbonatite contains more than 50% oxide and silicate minerals, and in the Valentine Township Carbonatite Complex rocks of this group likely formed as cumulate phases of the carbonatite magma.

In thin section, rocks of this group are fine grained, massive, equigranular, allotriomorphic with curved grain boundaries. Several specimens contain fractured grains. The mode is estimated as 0–60% biotite–phlogopite, 0–30% amphibole, 0–20% olivine, 0–20% apatite, 0–20% opaques, and 20–50% carbonate. Monazite and sphene were noted in trace to minor amounts in one thin section each.

Biotite–phlogopite occurs as anhedral tabular grains. Some grains have a patchy colour mottling and others have pale yellow-brown cores and dark red-brown rims. The zoned grains likely have phlogopite cores and biotite rims. Locally, biotite–phlogopite poikilitically encloses magnetite, carbonate, apatite, and sphene. The (001) cleavage is bent in places.

Amphibole is fine-grained, acicular, anhedral to subhedral and in places is pleochroic from colourless to pale green. The amphibole forms fine-grained mats of acicular crystals which have replaced possible former olivine. These clots are rarely outlined by dusty magnetite. In one specimen containing large amphibole grains, the amphibole encloses biotite and carbonate inclusions.

Olivine occurs in several thin sections and locally is extensively altered to serpentine, chlorite, carbonate, and dusty magnetite. It occurs as skeletal grains in several samples where it is intergrown with carbonate. The skeletal olivine has undergone alteration to chlorite, serpentine, and carbonate.

Apatite occurs as anhedral to subhedral grains that are round to round-elongate in plan view. Some samples contain apatite grains that appear fractured. Some of the larger apatite grains contain carbonate inclusions and fluid inclusions.

The opaques are considered to be magnetite. The mineral occurs as anhedral grains and is disseminated throughout. The magnetite is crudely skeletal in one sample. The larger magnetite grains enclose apatite, biotite and carbonate. The sphene occurs as anhedral to subhedral grains, some of which are wedge-shaped.

Monazite occurs as blocky euhedral crystals with a pattern of concentric zoning.

SOVITE

Rocks classified as sovite contain less than 50% total oxide and silicate minerals. The rocks of this group are fine grained, equigranular, massive, hypidiomorphic to allotriomorphic, with curved to straight grain boundaries. The mode is estimated as 1–10% amphibole, 0–20% biotite–phlogopite, 0–30% olivine, 0–20% magnetite, 0–20% apatite, and 50–100% carbonate. Trace to minor amounts of red–brown euhedral pyrochlore are present in several thin section. Sphene is present in trace amounts in one sample.

Amphibole occurs as euhedral, acicular, colourless crystals. It penetrates olivine grains and occurs as crudely radiating aggregates. The amphibole is preferentially associated with olivine. Some of the finer grained amphibole that occurs in clots may have replaced olivine. Table 2 gives a microprobe analysis of an amphibole crystal.

Biotite–phlogopite occurs as anhedral, tabular to crudely skeletal grains. Some of the grains are pleochroic with yellow–brown cores and dark brown rims. The colour variation between rim and core suggests compositional zoning of the grains from phlogopite cores to biotite rims. Some grains display a colour mottling which suggests an erratic compositional variation. The biotite–phlogopite locally encloses carbonate blebs and the (001) cleavage is locally bent. In one specimen an olivine grain is enclosed in biotite–phlogopite, and in another, apatite is enclosed. Table 2 gives a microprobe analysis of a mica grain.

Olivine occurs as round grains and as skeletal grains intergrown with carbonate. The olivine has altered to chondrodite, dusty magnetite, serpentine, carbonate, chlorite, and iddingsite. Chlorite and serpentine are the dominant alteration products and iddingsite is very common. The olivine commonly encloses carbonate and also encloses amphibole, apatite and sphene. Magnetite occurs as tiny grains disseminated along the margins of altered olivine grains. Chondrodite is

TABLE 2. MICROPROBE ANALYSES OF MINERAL GRAINS, VALENTINE TOWNSHIP CARBONATITE COMPLEX, SAMPLE V-2-3C, ANALYSES BY D. WATKINSON, CARLETON UNIVERSITY.

	1	2
Na_2O	8.07	0.71
FeO*	21.08	8.20
SiO_2	53.80	40.37
K_2O	1.97	8.21
MgO	8.23	26.07
MnO	0.00	0.04
Al_2O_3	0.03	9.23
CaO	0.20	0.00
Cr_2O_3	0.00	0.09
NiO	0.00	0.00
TiO_2	2.11	0.10
OH	1.95	4.06
TOTAL	97.46	97.08

1. Amphibole, centre of amphibole grain.
2. Mica grain.
* Total iron given as FeO.

present in trace amounts as a bright yellow, patchy replacement along the rim of some olivine grains.

The opaques are considered to be magnetite. The magnetite occurs as anhedral to subhedral disseminated grains. The magnetite encloses an occasional bleb of carbonate, and it is not uncommon that the magnetite appears crudely skeletal. Rarely the magnetite contains a grain of apatite or biotite.

Apatite occurs as anhedral to euhedral grains of round to round–elongate outline. Rarely, those specimens with large apatite grains may display a crudely skeletal form. The apatite is sometimes segregated into crude bands imparting a foliation to the rock. The larger apatite grains may enclose irregular carbonate blebs.

Carbonate occurs as an interlocking mosaic of anhedral grains. In one specimen of nearly pure carbonate, a mosaic of fine–grained carbonate separates larger carbonate grains, and suggests local recrystallization.

PETROLOGY

Relatively little can be said about the petrology of the Valentine Township Carbonatite Complex, due to lack of exposure and the likely possibility that other rock types exist within the body. Carbonatites are considered to be one part of an immiscible pair and thus the carbonatite examined represents only a portion of the original magma (LeBas and Handley 1979; Freestone and Hamilton 1980; Hamilton *et al.* 1979). The carbonatite magma was likely originally alkali– and volatile–rich and lost these components to the wall rocks (Gittins *et al.* 1975). The present carbonatite rocks therefore represent a residuum and not a melt. Therefore, the chemical compositions in Appendix A (Table A–2, A–3) cannot be used to postulate liquid compositions for petrological modelling.

The norms (Table A–4, Appendix A) were calculated after the method of LeBas (1973) and the statistical compositions of the lithologic units (Table A–5, Appendix A) after the method of Nie *et al.* (1975). The norms are given for comparative purposes only.

The skeletal olivine–carbonate intergrowths indicate rapid solidification of the carbonatite magma and have also been observed by the author in rocks of the Firesand River and Schryburt Lake Carbonatite Complexes.

GEOCHRONOLOGY

The Valentine Township Carbonatite Complex has not been isotopically dated. Until isotopic ages are available, the author tentatively considers the carbonatite to be Late Precambrian in age and thus part of the dominant alkalic rock–carbonatite emplacement event identified by Gittens *et al.* (1967) to have occurred in the Kapuskasing Subprovince.

The Valentine Township carbonatite occurs at the north end of the Kapuskasing Subprovince, where there are four ages of alkalic rock–carbonatite magmatism. The 1900 Ma event is represented by the Cargill Township, Argor, and Goldray Carbonatites Complexes, the 1100 Ma event by the Clay–Howells Alkalic Rock Complex and the 450 Ma event by the Hecla–Kilmer Alkalic Rock Complex. The Hecla–Kilmer Alkalic Rock Complex is intruded by younger lamprophyre dikes.

Reactivation of faults associated with the Kapuskasing Subprovince and alkalic rock–carbonatite intrusion has been repeated at least four times since the early Proterozoic.

METAMORPHISM

The presence of pyroxene, amphibole, biotite and carbonate in the fenitized gneisses suggest that iron, water, carbon dioxide and alkalies have been added to the gneissic wall rocks. Amphibole and pyroxene likely contain some of the alkali metals and biotite the potassium. One specimen appears somewhat poikiloblastic with large inclusion–filled biotite grains.

One carbonatite sample (sovite) consists of a mosaic of very fine–grained carbonate enclosing larger grains. The larger grains appear to have recrystallized along their grain boundaries and are therefore likely porphroclasts set in a deformed and recrystallized ground mass. This texture is rare and may reflect only local deformation and recrystallization. There is little evidence of metamorphism and recrystallization of the carbonate in nearly all of the samples examined.

STRUCTURAL GEOLOGY

Due to deep burial any structure internal or external to the complex is uncertain. Thin sections display variation in the relative quantities of the various mineral phases which produces the mineralogical banding. This banding is likely to be vertical to subvertical in orientation.

The complex has been emplaced into the northern portion of the Kapuskasing Subprovince of the Superior Province which is characterized by northeast–trending faulting. The complex is likely oval to dike–like in plan view and was likely emplaced into one of these fault zones. The long axis of the body probably trends northeast parallel to the regional structure.

The Kapuskasing Subprovince (Kapuskasing Structural Zone) has been reinterpreted by Percival and Card (1983). The structural zone is characterized by northeast–striking, northwest–dipping thrust faults which expose a 20 km oblique cross–section through the Archean crust (Percival and Card 1983). To the east, the thrust faulting places high–grade rocks in sharp contact with low–grade rocks; to the west, high–grade rocks grade into low–grade rocks over a distance exceeding 100 km (Percival and Card 1983). The interpretation of Percival and Card (1983) fit the geological observations for the region.

GEOPHYSICAL EXPRESSION

Figure 3 illustrates the aeromagnetic pattern over the carbonatite. The pattern is sufficiently detailed to postulate the presence of the carbonatite, however it is not sufficiently detailed to clearly define its contact with the enclosing gneisses.

The Valentine Township Carbonatite Complex has intruded the northern portion of the Kapuskasing Subprovince of the Superior Province. This subprovince is geophysically characterized by a northeast–trending zone of gravity highs and pronounced linear aeromagnetic trends (Innes 1960; ODM–GSC 1970). This anomalous zone has been interpreted to reflect an upwarp in the Conrad discontinuity caused by major regional faulting and the formation of an horst structure (Bennett *et al.* 1967; Wilson and Brisbin 1965).

The zone contains deeper level upper amphibolite and granulite facies rocks faulted into juxtaposition with greenschist facies rocks east and west of the structural zone (Bennett *et al.* 1967; Thurston *et al.* 1977; Percival and Card 1983).

RECOMMENDATIONS FOR FUTURE STUDY

In addition to more drilling, detailed geophysics is required to outline the intrusion. An isotopic age is desirable as well as other isotopic data. The minerals require microprobe analysis to complete positive identification for proper petrologic modelling.

Economic Geology

Preliminary drilling by Argor Explorations Limited located the carbonatite and identified sub–economic niobium and phosphorus mineralization over significant core lengths. Lost circulation and core above the complex suggests the possibility of residual accumulations on the surface of the intrusion but no attempt to identify such accumulations has been made. The complex has not been tested for rare earth elements or vermiculite.

PROPERTY DESCRIPTION

Argor Explorations Limited [1967]

The carbonatite was initially found by diamond drilling by Argor Explorations Limited in 1967. The company completed three holes for a total of 1504.2 m. Hole V2–3 encountered 77.1 m of 0.22% Nb_2O_5 and spotty assays over 3 m lengths of core in hole V2–2 returned phosphorus assays varying from 3.62 to 7.67%. The limited drilling has disclosed widespread but sub–economic niobium and phosphorus mineralization (see Figure 4).

RECOMMENDATIONS TO THE PROSPECTOR

The very limited examination of this carbonatite indicates that it remains an open target for additional testing. Drilling of the anomaly should be done with care to check the possibility that there is a residual accumulation of apatite, magnetite, vermiculite and pyrochlore on the weathered surface of the carbonatite below the unconformity with Paleozoic rocks.

Widespread niobium values offer encouragment for the location of more economic concentrations of niobium, and apatite appears to occur in sufficient concentration in the primary carbonatite to warrant consideration of its recovery in any mining endeavour. The rare earth element potential of the complex is unknown and warrants checking.

Appendix A — Petrographic Descriptions, Chemical Analyses, Normative Compositions, and Statistical Compositions of Lithologic Units of the Valentine Township Carbonatite Complex.

TABLE A-1. PETROGRAPHIC DESCRIPTIONS OF WHOLE-ROCK SAMPLES* FROM THE VALENTINE TOWNSHIP CARBONATITE COMPLEX.

Reference No. 1518
Sample No. V2 806.9-807.2

Magnetite, amphibole, apatite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved to straight grain boundaries. The long axes of some grains are subparallel, imparting a weak foliation to the rock. Amphibole is euhedral, acicular and colourless. Apatite forms anhedral to subhedral grains, which are rounded to rounded-elongate in outline. Opaques are subhedral to euhedral and disseminated throughout. Trace to minor olivine and biotite-phlogopite are present. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1519
Sample No. V2 1685.5-1685.8

Amphibole, biotite-phlogopite, apatite, magnetite, olivine sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved grain boundaries. Olivine is anhedral, rounded to irregular, often totally altered to iddingsite plus serpentine. Locally it is skeletal and encloses carbonate. Traces of chondrodite alteration are present. Dusty magnetite outlines some totally altered grains. Opaques are anhedral to euhedral, irregular and locally enclose carbonate blebs. Apatite is anhedral to subhedral, rounded to rounded-elongate. Amphibole is euhedral, colourless, and acicular. Biotite-phlogopite is subhedral, forming tabular crystals. Biotite-phlogopite locally encloses carbonate. Carbonate forms a mosaic of anhedral interlocking grains.

Reference No. 1520
Sample No. V2 1687.6-1687.8

Biotite-phlogopite, magnetite, amphibole, apatite, olivine sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved to straight grain boundaries. Biotite-phlogopite forms subhedral, tabular, pleochroic grains with yellow brown cores and dark reddish brown rims. It locally encloses blebs of carbonate. Opaques are subhedral to euhedral and disseminated. Amphibole is euhedral, acicular, and colourless. Olivine forms anhedral rounded grains, altered to reddish brown iddingsite and minor serpentine. Apatite occurs as anhedral to subhedral grains which are rounded to rounded elongate. Carbonate forms a mosaic of anhedral interlocking grains.

Reference No. 1521
Sample No. V2 1792.6-1793.3

Fenitized gneiss.

Fine grained, massive, equigranular, allotriomorphic, with curved to lobate grain boundaries. Clinopyroxene is anhedral, ragged, and colourless. Plagioclase (An12) is anhedral, irregular, contains carbonate, biotite, pyroxene, and has very lobate grain boundaries. Minor disseminated subhedral opaques are present. Biotite forms brown anhedral to subhedral grains interlocking with pyroxene. Minor acicular amphibole is pleochroic in green to colourless. Carbonate forms anhedral interstitial grains. Irregular patchy fine grained highly altered areas have the appearance of altered nepheline.

**All samples are from drill core. The locations of the drillholes are shown on Figure 3. The sample numbers consist of the drillhole number plus the depth of the core sample in feet.*

Reference No. 1522
Sample No. V2 1805.0-1805.6

Fenitized gneiss.

Fine grained, equigranular, massive, hypidiomorphic, with curved to lobate grain boundaries. Biotite forms anhedral to subhedral tabular grains; locally it encloses pyroxene, carbonate, apatite, and fine-grained alteration patches. Clinopyroxene is anhedral to subhedral and colourless. Minor apatite occurs as subhedral rounded to rounded-elongate grains. Carbonate is anhedral and interstitial. Alteration occurs in patches with occasional blocky outlines suggesting former nepheline. Plagioclase (An10) has lobate grain boundaries, and is poikiloblastic with inclusions of carbonate, pyroxene, apatite, biotite, and alteration patches.

Reference No. 1523
Sample No. V2 1872.4-1872.7

Albite (?) sovite.

Fine grained, massive, equigranular, hypidiomorphic, with straight to curved grain boundaries. Carbonate forms an interlocking mosaic of anhedral to euhedral grains. Feldspar forms anhedral to euhedral grains, which fill gaps between carbonate grains. Some feldspar is slightly granoblastic. The rock appears to be a contaminated sovite.

Reference No. 1524
Sample No. V2 1985.2-1985.5

Magnetite, amphibole, biotite-phlogopite, apatite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Magnetite is anhedral to subhedral and disseminated. Biotite-phlogopite is anhedral, irregular and has pale light-yellow brown cores and dark reddish brown rims. Amphibole is acicular, euhedral, and colourless. Apatite forms subhedral to anhedral, rounded to rounded-elongate crystals. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1525
Sample No. V2 1885.9-1886.9

Fenitized gneiss.

Fine grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Biotite forms anhedral, irregular, tabular grains. Small inclusions in the biotite have dark radioactive haloes and may be zircon. Biotite may enclose blebs of carbonate and clinopyroxene. Pyroxene forms anhedral to subhedral, somewhat ragged grains, which may enclose some carbonate. Irregular fine-grained patches appear to be possible nepheline. Plagioclase forms anhedral irregular grains, with some bending of albite twin planes. Plagioclase is poikiloblastic and encloses carbonate, alteration patches, pyroxene and biotite. Carbonate is anhedral and interstitial.

Reference No. 1526
Sample No. V2 2131.4-2132.2

Amphibole, magnetite, biotite-phlogopite, olivine sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved to straight grain boundaries. Olivine forms anhedral skeletal grains with traces of chondrodite alteration and minor serpentine alteration. Biotite-phlogopite forms anhedral, irregular, slightly tabular grains. Colour mottling of some grains suggests that it is variable in composition. Amphibole forms euhedral, acicular crystals. Magnetite is anhedral to subhedral and disseminated. It may enclose carbonate. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1527
Sample No. V2 2140.0-2140.7

Olivine, magnetite, biotite-phlogopite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved to straight grain boundaries. Olivine is anhedral, skeletal, with local extensive alteration to chondrodite, serpentine and chlorite. Magnetite is anhedral, disseminated and skeletal. Biotite-phlogopite is anhedral, tabular, encloses carbonate blebs and is irregular to nearly skeletal in outline. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1528
Sample No. V2 2151.9-2152.5

Amphibole, biotite-phlogopite, magnetite, apatite sovite.

Fine to medium grained, massive, equigranular, hypidiomorphic, with straight to curved grained boundaries. Biotite-phlogopite forms tabular grains, with bent (001) cleavage. Pleochroism of

light yellow brown cores and dark reddish brown rims suggests compositional zoning. It encloses carbonate and is crudely skeletal. Magnetite is anhedral, disseminated, skeletal, and may completely enclose carbonate blebs. Amphibole is minor and occurs as acicular, euhedral, colourless crystals. Apatite is anhedral; large grains are skeletal and enclose carbonate. Carbonate forms euhedral rhombs set in a mosaic of anhedral grains.

Reference No. 1529
Sample No. V2 2167.3-2167.6

Magnetite, biotite-phlogopite, olivine sovite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Olivine is skeletal and anhedral and is extensively altered to serpentine, possible chlorite and traces of chondrodite. Magnetite is anhedral, disseminated, skeletal, and may enclose blebs of carbonate. Biotite-phlogopite is anhedral, irregular, skeletal and may enclose carbonate. Pleochroism from light yellow brown cores to reddish brown rims suggests compositional zoning. Carbonate forms a mosaic of anhedral interlocking grains.

Reference No. 1530
Sample No. V2 2195.6-2196.0

Amphibole, biotite-phlogopite, olivine, magnetite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with straight and curved grain boundaries. Olivine is anhedral and skeletal with minor alteration to chondrodite and extensive alteration to serpentine and chlorite. Amphibole is acicular, euhedral, and may penetrate olivine. Amphibole may form into crudely radiating aggregates. Opaques are anhedral, disseminated, skeletal, and may enclose carbonate blebs. Biotite-phlogopite is anhedral and irregular; grains may enclose carbonate blebs and olivine grains. Pleochroism of light yellow brown cores and dark reddish brown rims suggests compositional zoning. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1531
Sample No. V2 2261.7-2262.0

Amphibole, apatite, magnetite, olivine, biotite-phlogopite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Biotite-phlogopite forms anhedral, irregular grains with curved grain boundaries. Pleochroism of light yellow brown cores and dark reddish brown rims suggests the grains are compositionally zoned. Apatite forms anhedral to subhedral, rounded to rounded-elongate grains. Magnetite is anhedral and disseminated. Olivine forms anhedral, rounded, nearly skeletal grains, which show extensive alteration to chlorite and serpentine. Amphibole forms acicular, colourless crystals. Carbonate forms a mosaic of anhedral grains.

Reference No. 1532
Sample No. V2 2269.0-2269.5

Magnetite, olivine sovite.

Fine to medium grained, equigranular, massive, hypidiomorphic, with curved grain boundaries. Olivine is rounded to subhedral in outline with chlorite and serpentine alteration along the edges. Olivine may enclose blebs of carbonate and grains of amphibole and sphene. Dusty magnetite occurs along fractures in olivine. Apatite forms subhedral, rounded to rounded-elongate grains. Carbonate forms interlocking mosaics of anhedral grains. Magnetite forms subhedral to anhedral disseminated grains. Sphene, amphibole, and biotite-phlogopite occur in only trace to very minor amounts.

Reference No. 1533
Sample No. V2 2296.0-2296.3

Magnetite, apatite, olivine, amphibole silicocarbonatite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. The rock contains some fractured grains. Amphibole is fine grained, acicular, and appears to be after olivine. Olivine occurs as anhedral rounded grains. Olivine is extensively altered to serpentine, chlorite, amphibole, and some dusty magnetite. Apatite forms anhedral grains, commonly in an interlocking aggregate. Magnetite forms anhedral to subhedral grains disseminated throughout. Carbonate forms an interlocking mosaic of interstitial grains.

Reference No. 1534
Sample No. V2 2308.2-2308.4

Magnetite, biotite-phlogopite, apatite, olivine sovite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Apatite is anhedral and forms rounded to rounded-elongate grains. Biotite-phlogopite forms anhedral

grains, which are irregular in shape, skeletal with carbonate and which enclose apatite grains. The (001) cleavage is bent. Olivine is anhedral, skeletal, nearly all replaced by chlorite, serpentine, and carbonate. Magnetite is anhedral, disseminated, and crudely skeletal. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1535
Sample No. V2 2346.5-2346.8

Sovite.

Fine grained, massive, inequigranular-seriate, allotriomorphic, with lobate grain boundaries. Carbonate grains with lobate grain boundaries form an interlocking mosaic. Fine grained carbonate mosaics occur between larger carbonate grains, suggesting some recrystallization along grain edges.

Reference No. 1536
Sample No. V2-3 790.0-790.5

Amphibole, biotite-phlogopite, magnetite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with straight to curved grain boundaries. Amphibole is acicular, euhedral and colourless. Apatite forms anhedral, rounded to rounded-elongate grains. Biotite-phlogopite forms anhedral, tabular crystals, pleochroic from light yellow brown cores to dark reddish brown rims. The (001) cleavage is bent. Magnetite is anhedral, disseminated and may enclose tiny biotite and carbonate grains. Carbonate is an anhedral interlocking mosaic.

Reference No. 1537
Sample No. V2-3 868.2-868.6

Apatite, magnetite, biotite-phlogopite sovite.

Fine to medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Biotite-phlogopite forms anhedral tabular, irregular grains; colour mottling suggests compositional variation. It encloses opaques, carbonate and apatite and rarely displays weak bending of (001) cleavage. Apatite forms anhedral to subhedral, rounded to rounded-elongate grains with small carbonate inclusions in larger grains. Opaques are anhedral, irregular, and may enclose apatite, biotite, and carbonate. Carbonate is anhedral and forms an interlocking mosaic. The thin section has high silicate-oxide mineral content but the drill core is greater than 50% carbonate, i.e., sovite.

Reference No. 1538
Sample No. V2-3 901.5-902.3

Apatite, magnetite, amphibole silicocarbonatite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Some apatite and magnetite grains appear fractured. Amphibole forms a very fine-grained mat of acicular crystals commonly outlined with dusty magnetite. Amphibole and magnetite appear to be after olivine. Apatite forms anhedral, rounded to rounded-elongate grains. Some grains consist of angular fragments. Biotite-phlogopite is minor and forms small tabular grains. Opaques are anhedral, disseminated, and may enclose small grains of biotite, carbonate and apatite. Some grains appear fractured. Carbonate forms anhedral, interstitial grains, commonly in mosaics.

Reference No. 1539
Sample No. V2-3 921.4-922.0

Amphibole, magnetite, apatite, biotite-phlogopite silicocarbonatite.

Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Traces of monazite occur as blocky crystals; concentric rings give a zoned appearance. Biotite-phlogopite forms irregular, anhedral grains with bent (001) cleavage, pale light yellow brown cores and dark reddish brown rims indicating compositional zoning. Biotite-phlogopite contains rounded blebs of carbonate. Apatite is anhedral, forming rounded to subrounded grains. Amphibole forms subhedral, acicular crystals. Opaques (magnetite) are anhedral and disseminated. Carbonate is anhedral and disseminated.

Reference No. 1540
Sample No. V2-3 1112.7-1113.2

Amphibole, magnetite, apatite, olivine, biotite-phlogopite silicocarbonatite.

Fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Some grains are fractured. Magnetite is anhedral and disseminated. Biotite-phlogopite is tabu-

lar, anhedral, and may enclose carbonate and magnetite. Some grains have patchy, dark reddish brown rims. Olivine forms anhedral, rounded, irregular grains. Olivine is altered to amphibole, chlorite and carbonate. Apatite forms anhedral to subhedral, rounded to subrounded grains, some of which are fractured. Amphibole is colourless, euhedral, acicular and clotty. Some clotty amphibole may be after olivine.

Reference No. 1541
Sample No. V2-3 1173.0-1173.4

Magnetite, apatite, olivine, biotite-phlogopite silicocarbonatite.

Fine to medium grained, equigranular, with curved grain boundaries. Biotite-phlogopite is anhedral and forms irregular, tabular grains which show some colour mottling. Carbonate-mica grain boundaries are lobate to curved. Olivine forms anhedral, skeletal grains and is replaced by chlorite, serpentine, and carbonate. Magnetite is anhedral, disseminated and crudely skeletal. Apatite is anhedral often elongate and encloses numerous blebs of carbonate. Some grains are fractured. Carbonate is anhedral and forms an interlocking mosaic.

Reference No. 1542
Sample No. V2-3 1235.7-1236.3

Magnetite, amphibole, biotite silicocarbonatite.

Fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Opaques are anhedral and disseminated. Amphibole is prismatic, ragged, anhedral to subhedral and pleochroic from colourless to pale green. It may enclose biotite and carbonate. Biotite forms anhedral, tabular grains and may enclose carbonate and sphene. Carbonate is anhedral and interstitial. Sphene is anhedral, wedge-shaped in places, and disseminated.

Reference No. 1543
Sample No. V2-3 1410.3-1411.0

Amphibole, magnetite, biotite-phlogopite, olivine, apatite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved grain boundaries. Olivine forms anhedral, crudely skeletal grains, which contain traces of chlorite, serpentine, and iddingsite. Olivine encloses carbonate blebs and an occasional apatite grain. Biotite forms anhedral, tabular grains. Amphibole is minor, fine-grained, acicular, euhedral and commonly associated with olivine grains. Apatite is anhedral to euhedral, and commonly forms elongate rounded grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1544
Sample No. V2-3 1491.4-1492.1

Magnetite, olivine, apatite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Olivine is anhedral, rounded, and completely altered to dusty magnetite, amphibole, carbonate, chlorite, and serpentine. Its outline is often skeletal. Apatite forms subhedral, rounded to rounded-elongate grains. Opaques are anhedral and disseminated. Carbonate is an interlocking mosaic of anhedral grains.

Reference No. 1545
Sample No. V2-3 1776.0-1776.2

Amphibole, magnetite, biotite-phlogopite, apatite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Biotite-phlogopite is anhedral and ragged with light yellow brown cores and dark reddish brown rims. Locally it encloses carbonate and is crudely skeletal. Opaques are anhedral and disseminated. Amphibole is euhedral, acicular and colourless. Apatite is anhedral and rounded to rounded-elongate in outline. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1546
Sample No. V2-3 1792.3-1792.6

Magnetite, apatite sovite.

Fine grained, equigranular, foliated, hypidiomorphic, with straight to curved grain boundaries. Magnetite is anhedral, disseminated and contains poikilitic apatite and carbonate. Oval clots of very fine-grained acicular amphibole and serpentine are possibly after olivine. Apatite forms anhedral, rounded to subangular grains, concentrated into bands. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1547
Sample No. V2-3 1798.7-1799.0

Olivine, biotite-phlogopite, apatite sovite.

Fine grained, equigranular, foliated, hypidiomorphic, with straight to curved grain boundaries. Olivine is anhedral, skeletal, intergrown with carbonate and extensively altered to serpentine

and chlorite along grain boundaries and fractures. Biotite-phlogopite forms anhedral, rounded grains concentrated in bands. Locally grains have their cleavage parallel to foliation. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1548
Sample No. V2-3 1997.5-1997.7

Amphibole, biotite-phlogopite, apatite sovite.

Fine grained, equigranular, foliated, hypidiomorphic, with curved to lobate grain boundaries. Biotite-phlogopite forms anhedral, ragged grains with pale yellow rims and dark reddish brown cores indicating compositional zoning. Amphibole is euhedral, acicular and colourless. Apatite forms euhedral to subhedral, rounded to rounded-elongate crystals, which may enclose carbonate. Apatite is concentrated into bands. Carbonate is anhedral, with lobate grain boundaries and forms interlocking mosaics.

TABLE A-2. MAJOR ELEMENT ANALYSES (WEIGHT PERCENT) OF WHOLE-ROCK SAMPLES FROM THE VALENTINE TOWNSHIP CARBONATITE COMPLEX.

	Sovite						
Ref. No.	1518	1519	1519*	1520	1543	1544	1545
SiO_2	5.21	5.87	5.84	4.06	8.18	7.16	6.84
Al_2O_3	0.56	0.56	0.57	0.41	0.52	0.53	0.80
Fe_2O_3	1.66	2.87	3.15	1.30	3.19	2.27	3.12
FeO	2.25	2.83	2.75	1.91	3.00	2.91	3.24
MgO	4.28	3.76	3.90	2.90	3.39	5.20	5.23
CaO	45.20	44.80	43.80	46.90	41.30	42.30	39.30
Na_2O	0.42	0.12	0.03	0.20	0.67	0.47	0.58
K_2O	0.45	0.33	0.33	0.18	0.26	0.39	0.61
TiO_2	0.24	0.20	0.25	0.06	0.31	0.20	0.16
P_2O_5	5.52	7.85	7.90	3.80	8.19	8.95	9.89
S	0.16	0.17	0.18	0.16	0.42	0.09	0.49
MnO	0.15	0.15	0.15	0.14	0.12	0.19	0.32
CO_2	33.60	29.50	29.60	36.60	27.30	29.00	29.70
H_2O+	0.00	0.27	0.38	0.15	0.05	0.35	0.00
H_2O-	0.30	0.45	0.47	0.40	0.31	0.27	0.23
Sum	100.0	99.7	99.3	99.2	97.3	100.3	99.5
S.G.	2.86	2.88	2.88	2.82	2.93	2.89	2.93

	Sovite						
Ref. No.	1524	1546	1547	1548	1523	1528	1529
SiO_2	4.00	4.98	4.47	4.70	4.52	9.19	9.04
Al_2O_3	0.43	1.29	0.50	0.63	0.82	1.38	0.86
Fe_2O_3	1.49	18.00	0.86	0.73	0.15	4.91	7.25
FeO	2.08	11.60	1.75	2.33	3.49	5.66	7.07
MgO	3.49	7.03	2.75	4.56	17.20	15.20	8.93
CaO	45.70	25.50	48.40	44.10	28.50	25.00	30.90
Na_2O	0.33	0.36	0.11	0.29	0.08	0.55	0.38
K_2O	0.21	0.09	0.24	0.35	0.00	0.71	0.38
TiO_2	0.06	0.63	0.05	0.00	0.00	0.76	1.17
P_2O_5	6.00	8.00	5.98	5.58	0.91	2.82	0.67
S	0.37	0.42	0.19	0.43	0.05	0.04	0.27
MnO	0.30	0.38	0.12	0.32	0.24	0.29	0.25
CO_2	33.30	19.40	33.90	35.20	41.60	31.90	29.20
H_2O+	0.03	0.00	0.00	0.00	0.00	0.09	0.21
H_2O-	0.18	0.41	0.28	0.35	0.55	0.50	0.38
Sum	98.0	97.1	99.6	99.6	98.1	99.0	97.0
S.G.	2.88	3.39	2.82	2.86	2.84	2.98	2.97

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1518	V2 806.9-807.2	1524	V2 1985.2-1985.5
1519	V2 1685.5-1685.8	1546	V2-3 1792.3-1792.6
1519*	V2 1685.5-1685.8	1547	V2-3 1798.7-1799.0
1520	V2 1687.6-1687.8	1548	V2-3 1997.5-1997.7
1543	V2-3 1410.3-1411.0	1523	V2 1872.4-1872.7
1544	V2-3 1491.4-1492.1	1528	V2 2151.9-2152.5
1545	V2-3 1776.0-1776.2	1529	V2 2167.3-2167.6

TABLE A-2. CONTINUED.

	Sovite							
Ref. No.	**1530**	**1531**	**1532**	**1532***	**1534**	**1535**	**1536**	**1537**
SiO_2	13.20	9.84	12.90	12.90	6.32	1.62	4.47	8.62
Al_2O_3	1.31	1.60	0.65	0.68	0.85	0.45	0.24	1.80
Fe_2O_3	16.60	4.16	17.50	1.71	2.22	0.00	1.91	6.27
FeO	12.60	3.66	12.20	12.30	4.49	0.75	2.00	5.16
MgO	11.30	7.78	12.30	12.10	8.36	1.64	2.55	3.81
CaO	18.80	34.40	20.50	20.10	35.70	50.30	43.80	37.30
Na_2O	0.44	0.48	0.29	0.04	0.57	0.45	0.47	0.40
K_2O	0.82	1.00	0.26	0.28	0.52	0.00	0.18	1.08
TiO_2	3.01	0.41	2.21	2.15	0.52	0.00	0.10	0.82
P_2O_5	0.28	7.85	1.31	1.14	6.20	0.20	5.72	13.0
S	0.57	0.18	0.11	0.10	0.31	0.02	0.22	0.28
MnO	0.40	0.21	0.43	0.42	0.26	0.13	0.18	0.16
CO_2	16.90	23.20	16.10	16.30	30.20	43.30	34.30	17.10
H_2O+	1.00	0.79	0.96	1.06	0.15	0.00	0.00	0.00
H_2O-	0.27	0.31	0.35	0.35	0.28	0.28	0.26	0.13
Sum	97.5	95.9	98.1	97.0	96.9	94.6	96.4	95.9
S.G.	3.31	2.94	3.31	3.31	2.96	2.73	2.84	3.08

	Sovite		Silicocarbonatite			
Ref. No.	**1526**	**1527**	**1533**	**1538**	**1539**	**1541**
SiO_2	14.50	9.01	16.50	12.50	24.20	10.30
Al_2O_3	1.37	2.01	0.88	0.57	3.46	2.18
Fe_2O_3	9.81	8.52	16.30	14.20	2.47	0.85
FeO	8.90	6.91	9.98	9.49	5.41	1.66
MgO	13.10	6.47	14.40	10.60	12.60	6.44
CaO	23.20	30.60	16.60	22.20	20.20	39.00
Na_2O	0.28	0.36	0.71	1.49	1.44	0.71
K_2O	0.78	1.27	0.50	0.45	3.21	1.24
TiO_2	1.60	1.57	1.91	1.25	0.56	0.19
P_2O_5	0.12	1.01	8.51	6.81	6.10	7.60
S	0.43	0.35	0.10	0.11	0.80	0.25
MnO	0.35	0.21	0.40	0.36	0.17	0.09
CO_2	20.80	27.60	9.99	17.70	14.50	25.50
H_2O+	2.22	0.16	2.38	0.03	0.62	0.53
H_2O-	0.24	0.30	0.32	0.20	0.32	0.32
Sum	97.7	96.4	99.5	98.0	96.6	96.8
S.G.	3.04	3.00	3.26	3.29	2.95	2.86

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1530	V2 2195.6-2196.0	1537	V2-3 868.2-868.6
1531	V2 2261.7-2262.0	1526	V2 2131.4-2132.2
1532	V2 2269.0-2269.5	1527	V2 2140.0-2140.7
1532*	V2 2269.0-2269.5	1533	V2 2296.0-2296.3
1534	V2 2308.2-2308.4	1538	V2-3 901.5-902.3
1535	V2 2346.5-2346.8	1539	V2-3 921.4-922.0
1536	V2-3 790.0-790.5	1541	V2-3 1173.0-1173.4

TABLE A-2. CONTINUED.

	Silicocarbonatite			Fenitized Gneiss		
Ref. No.	1542	1542*	1540	1521	1522	1525
SiO_2	30.70	30.20	13.50	42.30	43.50	40.90
Al_2O_3	8.44	8.62	0.82	11.90	14.20	10.00
Fe_2O_3	1.67	1.84	4.46	2.39	2.00	1.94
FeO	6.66	6.57	5.08	4.66	3.83	4.91
MgO	13.00	13.30	11.70	8.21	8.00	11.70
CaO	14.30	14.30	26.60	14.00	13.20	13.70
Na_2O	1.23	0.98	1.26	3.04	3.57	2.37
K_2O	5.79	5.86	0.47	3.55	3.55	4.24
TiO_2	3.12	3.13	0.98	0.53	0.38	0.27
P_2O_5	1.44	1.22	11.20	1.79	2.01	3.74
S	0.00	0.00	0.05	0.16	0.01	0.01
MnO	0.18	0.18	0.25	0.18	0.19	0.20
CO_2	11.30	11.30	20.60	4.43	3.15	4.50
H_2O+	0.47	0.43	0.33	1.48	1.06	1.42
H_2O-	0.39	0.36	0.23	0.29	0.32	0.11
Sum	98.7	98.3	97.5	98.9	99.1	100.0
S.G.	2.94	2.04	3.08	2.93	2.89	2.93

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1542	V2-3 1235.7-1236.3	1521	V2 1792.6-1793.3
1542*	V2-3 1235.7-1236.3	1522	V2 1805.0-1805.6
1540	V2-3 1112.7-1113.2	1525	V2 1885.9-1886.8

TABLE A-3. TRACE ELEMENT ANALYSES (PPM) OF WHOLE-ROCK SAMPLES FROM THE VALENTINE TOWNSHIP CARBONATITE COMPLEX.

	Sovite						
Ref. No.	1518	1519	1519*	1520	1543	1544	1545
Ag	<1	<1	-	<1	<1	<1	<1
Au							
As							
Ba	680	390	380	480	420	380	240
Be	<1	<1	-	<1	<1	<1	<1
Bi							
Co	11	11	9	8	11	11	11
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	14	11	8	12	12	13	25
Ga	1	2	-	1	3	1	3
Hg							
Li	8	8	10	8	8	12	6
Mn							
Mo	<3	<3	<3	<3	<3	<3	<3
Nb	150	90	70	<10	40	45	1500
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	17	<10	<10	<10	<10	16	<10
Rb	20	10	10	<10	10	10	20
Sb							
Sc	6	7	8	6	9	8	7
Sn	<1	1	-	<1	3	2	2
Sr	6000	7000	7000	7000	6000	4000	7000
Ti							
V	60	150	150	70	150	80	200
Y	90	80	80	80	70	80	70
Zn	76	50	48	32	40	58	49
Zr	1000	300	250	200	2000	1500	45
La	450	350	350	300	350	350	450
Nd	220	230	220	180	200	210	250
Ce	460	380	380	360	400	400	500
Yb	4	4	4	3	3	4	3
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1518	V2 806.9-807.2	1543	V2-3 1410.3-1411.0
1519	V2 1685.5-1685.8	1544	V2-3 1491.4-1492.1
1519*	V2 1685.5-1685.8	1545	V2-3 1776.0-1776.2
1520	V2 1687.6-1687.8		

TABLE A-3. CONTINUED.

	Sovite						
Ref. No.	1524	1546	1547	1548	1523	1528	1529
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	240	120	310	240	150	1320	330
Be	<1	2	<1	<1	<1	<1	5
Bi							
Co	8	19	8	9	5	13	38
Cr	<5	<5	<5	7	<5	<5	<5
Cu	17	7	12	16	8	43	72
Ga	2	4	1	<1	<1	4	4
Hg							
Li	8	4	7	8	4	8	14
Mn							
Mo	<3	<1	<3	<3	<3	<3	<3
Nb	7000	6000	40	900	500	150	250
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	13	32	<10	<10	<10	<10	<10
Rb	10	<10	10	10	<10	20	10
Sb							
Sc	8	20	<5	10	<5	9	10
Sn	2	17	1	1	<1	2	4
Sr	7000	2500	7000	7000	700	800	2000
Tl							
V	50	450	50	45	<10	150	300
Y	80	80	80	80	90	50	45
Zn	28	146	32	22	10	78	200
Zr	600	4000	300	250	300	300	300
La	600	200	300	450	250	150	100
Nd	220	220	150	190	220	170	160
Ce	400	400	340	440	420	280	260
Yb	4	7	5	4	5	2	2
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1524	V2 1985.2-1985.5	1523	V2 1872.4-1872.7
1546	V2-3 1792.3-1792.6	1528	V2 2151.9-2152.5
1547	V2-3 1798.7-1799.0	1529	V2 2167.3-2167.6
1548	V2-3 1997.5-1997.7		

TABLE A-3. CONTINUED.

	Sovite							
Ref. No.	**1530**	**1531**	**1532**	**1532***	**1534**	**1535**	**1536**	**1537**
Ag	<1	<1	<1	-	1	<1	<1	<1
Au								
As								
Ba	300	510	200	180	260	510	360	690
Be	<1	<1	<1	-	<1	<1	<1	<1
Bi								
Co	58	15	34	34	16	<5	9	17
Cr	<5	<5	<5	<5	<5	<5	<5	<5
Cu	75	14	10	8	18	10	10	19
Ga	9	3	7	-	2	1	1	4
Hg								
Li	10	4	6	6	6	6	6	5
Mn								
Mo	<1	<3	1	2	<3	<3	<3	<3
Nb	600	90	200	200	90	<30	50	100
Ni	<5	<5	<5	<5	<5	<5	<5	<5
Pb	<10	<10	<10	<10	<10	<10	<10	<10
Rb	20	30	<10	<10	10	<10	<10	30
Sb								
Sc	<5	15	30	30	<5	<5	<5	<5
Sn	8	<1	9	-	2	<1	<1	3
Sr	1500	3500	2000	2000	3500	9000	6000	3500
Ti								
V	600	150	700	700	150	<10	100	150
Y	30	70	35	35	70	70	80	80
Zn	250	66	230	210	146	16	94	126
Zr	350	2000	9000	9000	450	10	250	150
La	<100	250	<100	<100	300	400	250	300
Nd	90	190	100	110	230	220	170	310
Ce	180	320	220	220	380	460	340	520
Yb	3	3	3	3	2	4	5	5
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1530	V2 2195.6-2196.0	1534	V2 2308.2-2308.4
1531	V2 2261.7-2262.0	1535	V2 2346.5-2346.8
1532	V2 2269.0-2269.5	1536	V2-3 790.0-790.5
1532*	V2 2269.0-2269.5	1537	V2-3 868.2-868.6

TABLE A-3. CONTINUED.

	Sovite		Silicocarbonatite			
Ref. No.	1526	1527	1533	1538	1539	1541
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	490	820	100	140	550	1860
Be	<1	<1	<1	<1	2	<1
Bi						
Co	50	36	32	25	11	9
Cr	<5	<5	<5	<5	<5	<5
Cu	70	61	7	14	14	40
Ga	6	5	7	4	12	3
Hg						
Li	6	8	7	6	4	6
Mn						
Mo	<3	<3	4	<3	<3	<3
Nb	200	150	250	150	90	60
Ni	<5	<5	<5	<5	<5	<5
Pb	<10	<10	<10	<10	<10	<10
Rb	20	30	10	10	90	40
Sb						
Sc	10	6	<5	<5	50	9
Sn	5	3	9	5	3	1
Sr	2500	3000	1000	2500	800	3500
Ti						
V	300	300	600	350	80	35
Y	35	40	35	45	40	90
Zn	160	120	210	128	68	26
Zr	200	300	1000	600	7000	250
La	100	150	100	150	150	500
Nd	130	160	190	190	170	350
Ce	260	280	300	340	320	620
Yb	2	2	3	3	2	3
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1526	V2 2131.4-2132.2	1538	V2-3 901.5-902.3
1527	V2 2140.0-2140.7	1539	V2-3 921.4-922.0
1533	V2 2296.0-2296.3	1541	V2-3 1173.0-1173.4

TABLE A-3. CONTINUED.

	Silicocarbonatite			Fenitized Gneiss		
Ref. No.	**1542***	**1542**	**1540**	**1521**	**1522**	**1525**
Ag	<1	-	<1	1	<1	<1
Au						
As						
Ba	2060	2000	530	610	560	740
Be	2	-	1	2	1	2
Bi						
Co	24	25	22	20	12	12
Cr	21	22	<5	37	10	5
Cu	30	29	12	36	6	5
Ga	12	-	3	13	11	12
Hg						
Li	6	7	5	23	34	22
Mn						
Mo	<1	<1	<3	<1	<1	<1
Nb	450	450	250	300	150	600
Ni	26	25	<5	30	8	<5
Pb	44	48	<10	<10	<10	<10
Rb	130	140	10	50	60	80
Sb						
Sc	50	45	15	15	<5	15
Sn	10	-	18	2	1	2
Sr	1500	1500	3500	2500	2500	1000
Ti						
V	150	150	150	100	60	150
Y	30	30	90	15	<10	<10
Zn	92	92	52	80	80	99
Zr	350	350	2000	200	150	250
La	100	100	500	<100	<100	<100
Nd	120	120	420	60	70	60
Ce	240	220	780	120	120	100
Yb	<1	<1	4	<1	<1	<1
Ta	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
1542*	V2-3 1235.7-1236.3	1521	V2 1792.6-1793.3
1542	V2-3 1235.7-1236.3	1522	V2 1805.0-1805.6
1540	V2-3 1112.7-1113.2	1525	V2 1885.9-1886.8

TABLE A-4. NORMATIVE MINERALS (ALKALIC ROCKS) FOR WHOLE-ROCK SAMPLES FROM THE VALENTINE TOWNSHIP CARBONATITE COMPLEX.

	Sovite					
Ref. No.	1518	1519	1520	1543	1544	1545
QZ	1.67	2.77	2.75	6.23	2.98	3.60
CO	0.0	0.20	0.22	0.24	0.0	0.14
OR	2.66	1.95	1.06	1.53	2.30	3.60
AB	0.37	0.0	0.0	0.0	0.55	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.03	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.49	0.0	0.0	0.0	1.72	0.0
TH	0.71	0.27	0.46	1.54	0.40	1.33
GEH	0.0	0.0	0.0	0.0	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	0.0	0.0
D.EN	0.0	0.0	0.0	0.0	0.0	0.0
D.FS	0.0	0.0	0.0	0.0	0.0	0.0
FO	1.34	2.62	0.0	0.55	0.99	0.0
FA	2.46	2.40	2.08	2.39	3.33	3.07
ANDR	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0
MT	2.16	4.17	1.89	4.63	2.44	4.53
SPH	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.24	0.20	0.06	0.31	0.20	0.16
AP	13.07	18.58	8.99	19.39	21.18	23.41
CC	67.64	61.45	74.71	54.41	54.41	46.85
MGS	7.32	4.69	6.04	6.40	9.65	10.90
FL	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.30	0.72	0.55	0.36	0.62	0.28
SUM	100.42	100.03	98.22	97.99	100.78	97.87

QZ - Quartz; CO - Corundum; OR - Orthoclase; AB - Albite; LC - Leucite; KAL - Kalsilite; NEPH - Nepheline; CAR - Carnegieite; NS - Na_2SiO_3; AC - Acmite; TH - Thenardite; GEH - Gehlenite; AKM - Akermanite; FE-AK - Fe-Akermanite; D.WO - Wollastonite; D.EN - Enstatite; D.FS - Ferrosilite; FO - Forsterite; FA - Fayalite; ANDR - Andradite; HM - Hematite; MT - Magnetite; SPH - Sphene; PERV - Perovskite; RU - Rutile; AP - Apatite; CC - Calcite; MGS - Magnesite; FL - Fluorite; ZR - Zircon; BAD - Baddeleyite.

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1518	V2 806.9-807.2	1543	V2-3 1410.3-1411.0
1519	V2 1685.5-1685.8	1544	V2-3 1491.4-1492.1
1520	V2 1687.6-1687.8	1545	V2-3 1776.0-1776.2

TABLE A-4. CONTINUED.

	Sovite						
Ref. No.	**1524**	**1546**	**1547**	**1548**	**1523**	**1528**	**1529**
QZ	2.36	2.31	2.31	2.38	2.98	1.35	3.08
CO	0.20	1.19	0.24	0.25	0.82	0.0	0.45
OR	1.24	0.53	1.42	2.07	0.0	4.19	2.24
AB	0.0	0.0	0.0	0.0	0.0	3.14	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.75	0.0
TH	0.76	0.82	0.25	0.66	0.18	0.18	0.87
GEH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.EN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D.FS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FO	0.28	1.62	1.44	0.0	0.0	2.23	6.53
FA	2.43	5.52	2.11	3.30	5.20	5.48	5.77
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MT	2.16	26.15	1.25	1.06	0.22	6.76	10.53
SPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RU	0.06	0.63	0.05	0.0	0.0	0.76	1.17
AP	14.20	18.94	14.15	13.21	2.15	6.68	1.59
CC	67.40	26.68	72.26	65.53	48.68	37.96	53.53
MGS	6.94	12.70	4.00	9.50	35.84	29.00	10.77
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.21	0.41	0.28	0.35	0.55	0.59	0.59
SUM	98.24	97.51	99.77	98.32	96.64	99.06	97.12

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1524	V2 1985.2-1985.5	1523	V2 1872.4-1872.7
1546	V2-3 1792.3-1792.6	1528	V2 2151.9-2152.5
1547	V2-3 1798.7-1799.0	1529	V2 2167.3-2167.6
1548	V2-3 1997.5-1997.7		

TABLE A-4. CONTINUED.

	Sovite						
Ref. No.	1530	1531	1532	1534	1535	1536	1537
QZ	0.99	1.55	1.23	2.39	0.0	2.99	0.0
CO	0.42	0.30	0.24	0.29	0.0	0.0	0.0
OR	4.84	5.90	1.53	3.07	0.0	1.06	0.0
AB	0.0	1.12	0.65	0.0	1.28	0.23	0.0
LC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0	3.62
NEPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.56	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.27	0.0	0.0
AC	0.0	0.0	0.0	0.0	0.0	0.13	0.0
TH	1.01	0.80	0.49	1.31	0.09	0.97	0.92
GEH	0.0	0.0	0.0	0.0	0.0	0.0	1.70
AKM	0.0	0.0	0.0	0.0	0.0	0.0	28.33
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0	24.72
D.WO	0.0	0.0	0.0	0.0	0.0	0.0	-23.39
D.EN	0.0	0.0	0.0	0.0	0.0	0.0	-11.30
D.FS	0.0	0.0	0.0	0.0	0.0	0.0	-11.69
FO	15.75	6.64	19.19	0.85	0.0	0.0	7.26
FA	7.86	2.84	6.76	5.33	1.25	1.91	8.30
ANDR	0.0	0.0	0.0	0.0	0.0	0.0	9.28
HM	0.0	0.0	0.0	0.0	0.0	0.0	3.36
MT	24.12	6.04	25.42	3.23	0.0	2.71	0.0
SPH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0	1.40
RU	3.01	0.41	2.21	0.52	0.0	0.10	0.0
AP	0.66	18.58	3.10	14.68	0.47	13.54	3.08
CC	32.87	42.91	33.48	49.10	89.22	64.67	38.85
MGS	4.65	8.24	2.61	16.40	3.42	5.31	0.0
FL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	1.27	1.10	1.31	0.43	0.28	0.26	0.13
SUM	97.44	96.44	98.22	97.58	96.85	93.89	84.56

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1530	V2 2195.6-2196.0	1535	V2 2346.5-2346.8
1531	V2 2261.7-2262.0	1536	V2-3 790.0-790.5
1532	V2 2269.0-2269.5	1537	V2-3 868.2-868.6
1534	V2 2308.2-2308.4		

TABLE A-4. CONTINUED.

	Sovite		Silicocarbonatite			
Ref. No.	**1526**	**1527**	**1533**	**1538**	**1539**	**1541**
QZ	1.58	1.11	3.95	0.77	4.03	0.74
CO	0.53	0.64	0.0	0.0	0.49	0.47
OR	4.60	7.50	2.95	2.66	18.95	7.32
AB	0.0	0.0	1.74	0.43	0.0	1.92
LC	0.0	0.0	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0	0.0
NEPH	0.0	0.0	0.0	0.0	0.0	0.0
CAR	0.0	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0
AC	0.0	0.0	2.32	9.15	0.0	0.0
TH	0.64	0.82	0.44	0.49	3.30	1.11
GEH	0.0	0.0	0.0	0.0	0.0	0.0
AKM	0.0	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	0.0	0.0	0.0	0.0
D.EN	0.0	0.0	0.0	0.0	0.0	0.0
D.FS	0.0	0.0	0.0	0.0	0.0	0.0
FO	18.43	3.87	15.85	6.77	14.00	6.81
FA	6.87	4.67	4.84	6.94	6.35	1.94
ANDR	0.0	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0	0.0
MT	14.25	12.38	22.52	16.04	3.59	1.23
SPH	0.0	0.0	0.0	0.0	0.0	0.0
PERV	0.0	0.0	0.0	0.0	0.0	0.0
RU	1.60	1.57	1.91	1.25	0.56	0.19
AP	0.28	2.39	20.14	16.12	14.44	17.99
CC	41.09	52.19	9.62	23.59	21.70	51.70
MGS	5.19	8.84	10.99	13.96	9.45	5.25
FL	0.0	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	2.46	0.46	2.70	0.23	0.94	0.85
SUM	97.52	96.44	99.97	98.40	97.78	97.51

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1526	V2 2131.4-2132.2	1538	V2-3 901.5-902.3
1527	V2 2140.0-2140.7	1539	V2-3 921.4-922.0
1533	V2 2296.0-2296.3	1541	V2-3 1173.0-1173.4

TABLE A-4. CONTINUED.

	Silicocarbonatite		Fenitized Gneiss		
Ref. No.	1542	1540	1521	1522	1525
QZ	0.0	3.95	0.0	0.0	0.0
CO	0.15	0.0	0.0	0.0	0.0
OR	14.66	2.77	20.89	19.09	23.60
AB	0.0	1.60	22.92	24.76	15.85
LC	12.42	0.0	0.0	0.0	0.0
KAL	0.0	0.0	0.0	0.0	0.0
NEPH	7.73	0.0	0.13	3.91	2.99
CAR	0.0	0.0	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0
AC	0.0	7.26	0.0	0.0	0.0
TH	0.0	0.22	0.71	0.04	0.04
GEH	0.0	0.0	9.58	12.14	4.15
AKM	0.0	0.0	0.0	0.0	0.0
FE-AK	0.0	0.0	0.0	0.0	0.0
D.WO	0.0	0.0	3.52	2.90	2.38
D.EN	0.0	0.0	2.42	2.05	1.71
D.FS	0.0	0.0	0.82	0.59	0.46
FO	20.08	2.34	12.57	12.45	19.12
FA	8.65	6.33	4.71	3.97	5.66
ANDR	0.0	0.0	0.0	0.0	0.0
HM	0.0	0.0	0.0	0.0	0.0
MT	2.43	2.83	3.47	2.91	2.82
SPH	0.0	0.0	1.30	0.93	0.66
PERV	0.0	0.0	0.0	0.0	0.0
RU	3.12	0.98	0.0	0.0	0.0
AP	3.41	26.51	4.24	4.76	8.85
CC	22.12	21.13	10.07	7.16	10.22
MGS	2.99	21.57	0.0	0.0	0.0
FL	0.0	0.0	0.0	0.0	0.0
ZR	0.0	0.0	0.0	0.0	0.0
BAD	0.0	0.0	0.0	0.0	0.0
H_2O	0.86	0.56	1.77	1.38	1.53
SUM	98.61	98.06	99.11	99.06	100.06

Note: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1542	V2-3 1235.7-1236.3	1522	V2 1805.0-1805.6
1540	V2-3 1112.7-1113.2	1525	V2 1885.9-1886.8
1521	V2 1792.6-1793.3		

TABLE A-5. AVERAGE CHEMICAL COMPOSITIONS (WEIGHT PERCENT AND PPM) OF LITHOLOGIC UNITS FOR THE VALENTINE TOWNSHIP CARBONATITE COMPLEX.

	Sovite (N = 24)		Silicocarbonatite (N = 7)		Fenitized Gneiss (N = 3)	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
SiO_2	7.39	3.41	19.70	8.57	42.23	1.30
Al_2O_3	0.87	0.48	3.64	3.54	12.03	2.10
Fe_2O_3	5.63	5.90	5.97	6.46	2.11	0.24
FeO	5.08	3.76	6.41	2.82	4.47	0.57
MgO	6.97	4.40	11.72	2.62	9.30	2.08
CaO	36.10	10.00	21.89	8.77	13.63	0.40
Na_2O	0.35	0.18	1.12	0.32	2.99	0.60
K_2O	0.45	0.34	2.50	2.47	3.78	0.40
TiO_2	0.69	0.84	1.59	1.18	0.39	0.13
P_2O_5	4.47	3.30	4.69	3.29	2.51	1.07
MnO	0.24	0.10	0.23	0.11	0.19	0.01
CO_2	28.48	7.77	15.84	5.73	4.03	0.76
S	0.25	0.16	0.19	0.28	0.06	0.09
H_2O+	0.33	0.53	0.68	0.77	1.32	0.23
H_2O-	0.33	0.10	0.31	0.07	0.24	0.11
LOI	27.44	7.56	16.53	5.56	6.13	0.50
TOTAL	98.13	1.39	97.91	1.03	99.33	0.59
S.G.					2.92	0.02
Ag	<0.91	0.43	<1.00	0.00	<0.33	1.15
Co	18.17	15.30	21.14	8.23	14.67	4.62
Cr	<4.50	2.45	2.57	12.93	17.33	17.21
Cu	23.54	22.35	20.86	12.12	15.67	17.62
Li	7.33	2.43	5.86	1.07	26.33	6.66
Ni	<5.00	0.00	3.71	14.89	11.00	17.69
Pb	<5.08	11.64	6.00	27.35	<10.00	0.00
Zn	95.29	72.52	95.43	60.10	86.33	10.97
Be	<0.59	1.40	0.33	1.51	1.67	0.58
Mo	<2.46	1.35	<1.43	2.57	<1.00	0.00
Sc	6.83	10.09	22.71	25.06	8.33	11.55
Sr	4479.17	2468.23	2042.86	1131.16	2000.00	866.03
V	209.79	207.03	216.43	195.68	103.33	45.09
Y	66.67	19.49	51.43	26.88	<1.67	14.43
Ga	2.82	2.46	6.83	4.25	12.00	1.00
Nb	765.62	1804.58	242.86	158.82	350.00	229.13
Rb	8.75	13.93	61.43	57.86	63.33	15.28
Zr	1377.29	2512.93	1650.00	2436.19	200.00	50.00
Ta	<1.00	0.00	<1.00	0.00	<1.00	0.00
Sn	2.68	4.21	7.67	6.12	1.67	0.58
Ba	416.67	261.18	1034.29	897.03	636.67	92.92
Yb	3.58	1.25	1.86	2.04	<1.00	0.00
Ce	358.33	90.78	402.86	212.42	113.33	11.55
La	254.17	180.53	228.57	186.76	<100.00	0.00
Nd	189.58	50.86	22.86	116.29	63.33	5.77

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Index

A

Aeromagnetic data, 8, 12
  Map, 6, 7
Amphibole
  Fenite, 9
  Silicocarbonatite, 9
  Sovite, 10
    Microprobe analyses, 10
Analyses
  Average chemical compositions
    Gneiss, Fenitized, 34
    Silicocarbonatite, 34
    Sovite, 34
  Major element
    Gneiss, Fenitized, 23
    Silicocarbonatite, 22—23
    Sovite, 21—22
  Microprobe, Sovite, 10
  Normative minerals
    Gneiss, Fenitized, 33
    Silicocarbonatite, 32—33
    Sovite, 29—32
  Trace element
    Gneiss, Fenitized, 28
    Silicocarbonatite, 27—28
    Sovite, 24—27
Apatite, 14
  Fenite, 9
  Silicocarbonatite, 9
  Sovite, 11
Argor Explorations Ltd., Property description, 14

B

Banding, 12
Biotite, Fenite, 9
Biotite-phlogopite
  Silicocarbonatite, 9
  Sovite, 10

C

Carbonate
  Fenite, 9
  Sovite, 11
Carbonatite
  Metamorphism, 12
  Weathered, 6
Carbonatite - alkalic rock complexes, Map, 4
Chondrodite, Olivine, Sovite, 10
Clinopyroxene, Fenite, 8

D

Diamond drillhole
  Map, 7
  Section, 7

E

Economic geology, 14

F

Faults, 12
Fenite, Petrology, 8—9
Fenitization, Granitic gneiss, 8

G

Geochronology, 11
Gneiss
  Fenitized
    Analyses
      Average chemical compositions, 34
      Major element, 23
      Normative minerals, 33
      Trace element, 28
    Metamorphism, 12
  Petrology, 15, 16
Granitic gneiss, Fenitized, 8

H

Horst structure, 12

K

Kapuskasing Subprovince, 12
Kwataboahegan formation, 6

L

Late Precambrian, Petrology, 8—11
Lithologic units, Table, 8

M

Magma, Carbonatite, Petrology, 11
Magnetite, 14
  Olivine, Sovite, 10
  Silicocarbonatite, 9
  Sovite, 11
Metamorphism, 12
Mica, Sovite, Microprobe analyses, 10
Monazite, Silicocarbonatite, 9

N

Niobium, 14

O

Olivine
  Silicocarbonatite, 9
  Sovite, 10
Overburden, 6

P

Paleozoic, 6
Petrology, 11
Phosphorus, 14
Plagioclase, Fenite, 8—9
Pyrochlore, 14

R

Rare earth element, 14
Recommendations
  Future study, 13
  Prospector, 14
Residuum, 6, 14
Rims, Biotite–phlogopite, Sovite, 10

S

Sextant Rapids formation, 6
Silicocarbonatite
  Analyses
    Average chemical compositions, 34
    Major element, 22—23
    Normative minerals, 32—33
    Trace element, 27—28
  Nomenclature, 3
  Petrology, 9, 17, 18, 19
Sovite
  Analyses
    Average chemical compositions, 34
    Major element, 21—22
    Microprobe, 10
    Normative minerals, 29—32
    Trace element, 24—27
  Metamorphism, 12
  Nomenclature, 3
  Petrology, 10—11, 15, 16, 17, 18, 19, 20
Sphene, Silicocarbonatite, 9
Structural geology, 12

V

Vermiculite, 14

Z

Zircon, Biotite, Fenite, 9
Zoning
  Biotite–phlogopite, Silicocarbonatite, 9
  Monazite, Silicocarbonatite, 9